IS 7620-2 (1986): Diagnostic Medical X-ray Equipment, Part 2: Performance Requirements [MHD 19: Immuno-Biological Diagnostic Kits]

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Indian Standard

SPECIFICATION FOR DIAGNOSTIC MEDICAL X-RAY EQUIPMENT

PART 2 PERFORMANCE REQUIREMENTS

(First Revision)

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Indian Standard

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PART 2 PERFORMANCE REQUIREMENTS

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(First Revision)

0. FOREWORD

0.1 This Indian Standard (First Revision) was adopted by the Indian Standards Institution on 16 June 1986, after the draft finalized by the Electromedical Equipment Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 This Indian Standard was first published in 1975, and is revised in two parts incorporating certain modifications, particularly in respect of momentary output and leakage current test.

0.3 While Part 1 of the this standard specifies general and safety requirements, Part 2 specifies performance requirements of diagnostic medical x-ray equipment.

0.4 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard (Part 2) specifies performance requirements for all types of diagnostic medical x-ray equipment (and parts thereof) as defined in Part 1 of this standard.

*Rules for rounding off numerical values (*revised*).

2. TERMINOLOGY

2.0 For the purpose of this standard, the definitions as given in IS : 1885-(Part 43/Sec 2)-1977* and Part 1 of this standard, shall apply.

3. GENERAL REQUIREMENTS

3.1 Physical and Mechanical Requirements

3.1.1 X-ray equipment should employ materials throughout which are suitable for the particular use and should be made and finished with the degree of uniformity and grade of workmanship fit for this particular equipment.

3.1.2 Attachment plugs, circuit-breakers, cords, fuseholders, fuses, lampholders, motor-operated components, receptacles, switches, etc, which are provided as parts of x-ray equipment shall be chosen with respect to their suitability for the particular application and shall conform to appropriate Indian Standard. In case an Indian Standard is not available it will be as agreed to between the manufacturer and the purchaser.

3.1.3 The enclosure shall be so formed or provided with barriers that the supporting surface will be protected against ignition by falling brands or molten material in the event of failure of the equipment.

3.1.4 For unreinforced, flat surfaces in general, cast metal should be not less than 3 mm in thickness, except that malleable iron may be not less than 2·3 mm in thickness and die-cast metal may be not less than 2 mm in thickness. Corresponding thickness of not less than 1·2, 1·5 and 1·2 mm respectively, may be acceptable if the surface is curved, ribbed, or otherwise reinforced, or if the shape and/or size of the surface is such that adequate mechanical strength is provided.

3.1.5 Equipment shall be built in such a manner that its electrical insulation may not be affected adversely by water condensing on the cold surfaces, by water leaking from receptacles, hoses, couplings and the like.

3.1.6 It shall not be possible to fix in a wrong position actuating parts which indicate the setting of switches or setting devices, the incorrect operation (incorrect setting) of which may be the cause of danger to patient or user (for example, mains switches, circuit-breakers or power controls), as well as actuating parts which have to be removed in use.

3.2 Switches, Fasteners and Other Components

3.2.1 Switches, lamp holder, attachment plug, receptacle plug connection, or similar device shall be mounted securely and prevented from turning by means other than friction between surfaces.

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*Electrotechnical vocabulary : Part 43 Electrical equipment used in medical practice.

3.2.2 Screws, washers and nuts of insulating materials shall not be used if there is danger of their being replaced during maintenance or repairs by commercial metal parts and the protective insulation or reinforced insulation is adversely affected thereby.

3.2.3 Protective sleeving shall only be used as supplementary insulation on insulated internal wires and shall be held in position by suitable means.

3.2.4 Fluoroscopic screens whenever provided with the x-ray equipment shall have light-proof cover.

3.3 Corrosion Protection

3.3.1 Iron, steel, aluminium and any other metallic part shall be suitably protected against corrosion by enamelling, painting, galvanizing, plating or other equivalent means.

3.3.2 Equipment subject to spillage of liquid in normal use shall be constructed in such a manner that its electrical insulation is not adversely affected by such spillage.

3.3.3 The equipment shall withstand the effect of normal atmospheric humidity.

3.3.4 Equipment which contains batteries shall be built in such a manner that the insulation is not adversely affected by leaking acid or alkali.

3.3.5 All part of the equipment including electric parts should be so treated as to avoid the growth of fungus in normal use and storage.

3.4 Temperature Rise — Materials employed in the construction of x-ray equipment shall not be affected adversely by the temperature attained under any condition of normal operation and also under condition of normal idling (12 hours). The temperature-rise of different parts and materials shall not exceed the values given in Table 1 of Part 1 of this standard.

3.5 Supply Connections

3.5.1 The equipment which is not intended to be permanently connected to a fixed installation shall be provided either with a permanent connection lead or appliance inlet suitable to be connected with the appliance connector without difficulty.

3.5.2 Either rubber insulated flexible cords conforming to IS : 9968 (Part 1)-1977* or PVC insulated flexible cords conforming to IS : 694-1977† shall be used for the above connection.

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*Specification for rubber-insulated cables: Part 1 With copper conductors (*revised*).
†Specification for PVC insulated cables (for working voltages up to 1 100 volts).

3.5.3 Equipment intended for permanent connection to stationary installation shall be provided with lead entries, conduit entries or glands of proper sizes.

3.5.4 Equipment for permanent stationary connection shall be provided with terminals which permits connection by screws or nuts.

3.5.5 Terminals shall be constructed in such a manner that the conductors are clamped with adequate contact pressure between metal surfaces without damage to the conductors.

3.5.6 Bolted terminals shall be provided with washers of appropriate sizes.

3.5.7 The mains connection terminals including the protective conductor terminals shall be arranged specially close together.

3.6 Wiring and Wiring Terminals

3.6.1 The wiring and connections between parts of x-ray equipment shall be adequately protected or enclosed, except that a suitable length of flexible cord or cable may be employed for external wiring or for interconnection between various components of the equipment if flexibility is essential.

3.6.2 An insulated conductor shall not be exposed to oil, grease, oily vapour, or other substance liable to affect insulation adversely unless the insulating compound has been recognized as being suitable for such usage.

NOTE — A conductor is considered to be exposed to oil if it touches an oil-filled enclosure, unless that enclosure is completely sealed.

3.6.3 Aluminium conductors should not be used for internal wiring.

3.7 Live Metal Parts

3.7.1 A metal other than silver, copper, or a copper alloy employed for current-carrying parts shall be suitable for the particular application.

3.7.2 Carbon and certain tungsten alloys are among the materials which are acceptable for contacts.

3.8 X-ray Table

3.8.1 Height of the table top from floor level when physically measured should not be more than 870 mm.

3.8.2 Table top material shall be of uniform density and shall not cast any shadow when viewed with x-ray on a screen and shall not have any void or foreign material to interfere with fluoroscopic or radiographic examination.

3.8.3 The table top shall be of such material so that it can be washed with cold soap water. It shall not have any deterimental effect on application of chemical/dyes used in special radiographic investigation.

3.8.4 The filtration of table top shall be specified and shall not be more than 1 mm of aluminium at 80 kV_P.

3.8.5 The table top, when physically checked, shall be capable of taking 100 kg distributed load at horizontal position without any appreciable sag at the middle of the table top. The sag shall not be more than 10 mm.

3.8.6 The motor driven table shall be capable of raising 100 kg load on the head end of the table from any position of the chassis tilt.

3.8.7 Screen frame or spot film device shall be parallel and square with table top within 3·00 mm per 300 mm in all positions of the chassis.

3.8.8 Maximum drag, that is, force in kg to overcome friction at minimum constant speed for screen spot film carriage and bucky in tilt table shall be specified by the manufacturer with locks off and on for tilt table as indicated in the following table:

Part	*Table in Horizontal Position*		*Table in Vertical Position*	
	Locks Off	Locks On	Locks Off	Locks On
Screen/sport film carriage				
Longitudinal travel				
Cross Travel				
Compression movement				
Bucky				
Longitudinal				

3.8.9 Maximum travel of screen/spot film device and bucky shall be specified by the manufacturer as in the following table:

Part	*Travel*
Screen/sport film device	Longitudinal — mm
	Cross — mm
	Compression — mm
Bucky	Longitudinal — mm

3.8.10 The screen frame or spot film device shall be coupled with the tube head in such a manner that both move together firmly.

3.9 Tubestand

3.9.1 Maximum and minimum travel of tube focus from ground shall be specified.

3.9.2 Maximum longitudinal movement of tube focus shall be specified.

3.9.3 Maximum and minimum cross travel of the focus shall be specified.

3.9.4 Maximum drag, that is, force in kg to overcome friction at minimum constant speed shall be specified according to the following table:

Movement	*Force* kg	
	Locks Off	Locks On
Vertical		
Horizontal		
Cross		

3.10 Collimator

3.10.1 Visual means shall be provided to find out the approximate radiated area without energizing x-ray at distances at which radiographs are taken normally.

3.10.2 Where light beam or other visual means are provided to find out the area to be exposed the indicated area shall be at least 2 mm more than the actual exposed area at a distance of 1 m.

3.10.3 Central beam shall be within 3 mm of the centre of the film/ screen.

4. MARKINGS

4.1 X-ray apparatus and parts thereof, in so far as they form a separable component, shall be provided with permanently and clearly legible markings as given in Part 1 of this standard.

5. CATEGORIES OF TESTS

5.1 General — Tests are broadly classified into two categories, namely, type tests and routine tests.

5.1.1 The following shall constitute the type tests:

a) Test for accuracy of indication for the x-ray control (*see* **6.2**);

b) Test for stabilization with internal temperature changes for the x-ray control (*see* **6.3**);

c) Recycling time test for the x-ray control (*see* **6.4**) (where required);

d) Milliampere stabilization test for the x-ray control (*see* **6.5**);

e) Timer test for x-ray control (*see* **6.6**);

f) Stator voltage and current test (**6.7**);

g) Test for interlocks (**6.8**);

h) Installation test (*see* **6.9**);

j) Grid pattern test (for potter bucky and x-ray grid) (*see* **6.10**);

k) Grid clear up test (for potter bucky and x-ray grid) (*see* **6.11**);

m) Potter bucky motion and synchronism test grid (*see* **6.12**);

n) Exposure angle and location of objective plane test for body section devices (*see* **6.13.1**);

p) Flatness of plane test (**6.13.3**);

q) Tomographic resolution test (*see* **6.13.4**);

r) Section thickness test (*see* **6.13.5**);

s) Magnification test for body section devices (**6.13.6**);

t) Test on x-ray table (*see* **6.14**); and

u) Test on tube stand (*see* **6.6**).

5.1.2 A test certificate may be produced in lieu of the actual type test specified under (j) to (r).

5.1.3 The following shall constitute the routine tests:

a) Visual examination and inspection (*see* **6.1**);

b) Timer test for x-ray control (*see* **6.6**);

c) Stator voltage and current test (*see* **6.7**);

d) Test for interlocks (*see* **6.8**);

e) Installation test (*see* **6.9**); and

f) Test on x-ray table (*see* **6.14**).

6. TESTS

6.0 General — During tests for accuracy of indication, stabilization with internal temperature changes, recycling, milliampere stabilization, timer, stator voltage and current, interlocks, and meters installation and spinning top, the mains resistance shall not exceed the values shown in Table 1.

6.0.1 Method of calculation and measurement of mains resistance and momentary output is shown in Appendix B of Part 1 of this standard.

TABLE 1 MAINS RESISTANCE AND CORRESPONDING MOMENTARY OUTPUT OF DIAGNOSTIC X-RAY GENERATORS

(*Clause* 6.0)

Type of Generator	Maximum kVp	Maximum Current Output in mA	Maximum Momentary Rating in kW	Mains Resistance in ohms at 240 V Line	Mains Resistance in ohms at 415 V Line	No. of Phases	Recommended 3/1 Phase Conversion Transformer in kVA	Slow Blow Fuse Rating A
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Single pulse	50	7	0·3	1·6	—	—	Not required	6
	65/85	20/15	1·0	1·0	3·0	1	Not required	10
	100	25	2·0	0·6	2·0	1	Not required	10
	80/90/100	60/50/40	3·8	0·4	1·2	3 or 1	10	20
	100	100	8·0	0·2	0·6	3 or 1	20	20
Two pulse	100	100	8·0	0·4	1·2	3 or 1	10	20
	100	160	12·8	0·3	1·9	3 or 1	15	25
	100/125	200/100	16·0	4·2	0·6	3 or 1	20	30
	100/125	300/200	24·0	—	0·5	3	30	35
	70/100/125	700/500/300	40·0	—	0·2	3	50	60
	100/125/150	500/400/300	40·0	—	0·2	3	50	60
Six and twelve pulse	100/125/150	300/250/200	32·0	—	0·5	3	Not applicable	25
	100/125/150	500/400/300	50·0	—	0·3	3	Not applicable	35
	100/125	1 000/800	100	—	0·2	3	Not applicable	60

6.1 Visual Examination and Inspection — The diagnostic x-ray equipment shall be visually examined, measured and inspected for conformity with the relevant requirements specified.

6.2 Test for Accuracy of Indications

6.2.1 *Peak Kilovolts* — The peak kilovolts shall be determined with a peak voltage measuring instrument at 70 and 40 percent of rated output voltage at various radiographic milliampere levels indicated on the x-ray equipment but not exceeding the milliamperes for designated output voltage, and at a fluoroscopic levels of approximately 3 milliamperes.

Care and caution shall be taken to keep all high voltage circuits away from ground and to make certain that personnel avoid contact with exposed high-voltage system.

6.2.1.1 *Test value* — The values indicated on the peak kilovoltmeter and the x-ray equipment indications shall not differ by more than ± 4 percent.

6.2.2 *Milliamperes* — This test is intended to be used as a proof test to determine the true anode current and may be used as a calibration means for the existing current indications of the x-ray equipment.

This test uses a comparison of the indication of added test instruments with the indicating means of the x-ray control. These added test instruments shall be D'Arsonval type milliammeters with an accuracy of ± 1 percent of full scale. If a milliampere-second meter is required, it shall have an accuracy of ± 5 percent of full scale.

The test instrument shall be connected into the grounded lead of this high voltage generator. If the current is alternating at this point, it shall be rectified by a suitable full wave bridge rectifier. Kilovoltage on the x-ray equipment shall be set at the lowest reasonable value to prevent flashover.

The test instrument should not be touched as it will be at a lethal potential.

Exposures shall be made at 100 percent and at approximately 70 and 40 percent of the range of each current indicator on the equipment. The test instrument indication and the x-ray equipment indication shall be recorded.

The mA indicator may consist of either a meter, dial, push button, or calibration chart for programmed x-ray control.

6.2.2.1 *Test value* — The test instrument indication and the x-ray equipment indicator shall be compared. The difference between these readings shall not exceed the following limits:

a) Radiograpic
X-ray equipments with rated output current ⩽ 300 mA 8 percent
X-ray equipments with rated output current > 300 mA 5 percent

b) Fluoroscopic
All x-ray equipments 10 percent

6.3 Test for Stabilization With Internal Temperature Changes — The x-ray control shall be supplied with rated line voltage after being de-energized for at least 4 hours. It shall then be energized and the peak kilovoltage set at 75 percent of rated output voltage. At the end of 5 minutes, three 0·2 second exposures shall be made at approximately 25, 50 and 75 percent of rated output current. The values of milliamperes shall be recorded as ‘ milliamperes for cold unit ’.

The control shall be energized (but not operated) for 8 hours. At the end of this time, the exposures called for as above shall be repeated. The values of milliamperes obtained shall be recorded as ‘milliamperes for hot unit’.

6.3.1 *Test Value* — The values of ‘milliamperes for hot unit’ shall be compared with the values of ‘milliamperes for cold unit’. The difference between these values shall not exceed the specified percentage given below:

X-ray equipments with rated output current ⩽ 300 mA 20 percent
X-ray equipments with rated output current > 300 mA 10 percent

6.4 Recycling Time Test

6.4.0 This test applies only to x-ray equipments in which load switching if performed in the high-voltage generator primary circuit. A typical test method is given in **6.4.1** to **6.4.6**.

6.4.1 *Automatic Test Device* — The automatic test device shall consist of a full-wave bridge rectifier, the alternating-current terminals of which are connected to the control circuit of the timer being checked in place of the exposure push button switch. These connections shall be made through terminals A and B. The direct current terminals of the bridge shall be made shunted with a sensitive silicon controlled rectifier and an adjustable firing circuit (*see* Fig. 1).

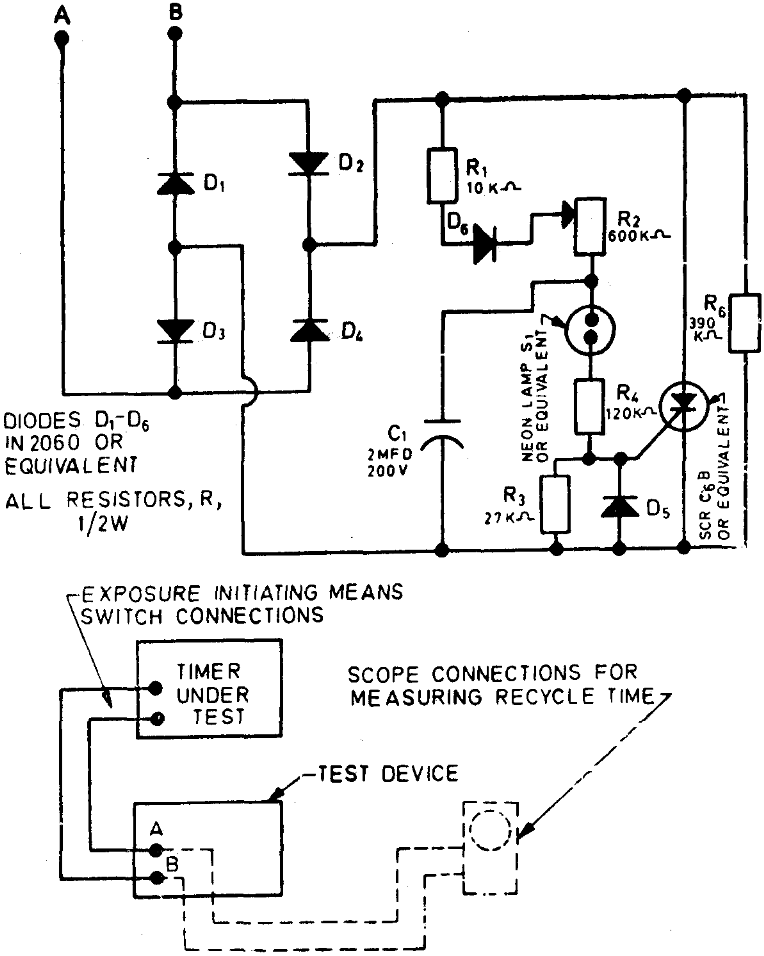


FIG. 1 TEST DEVICE — AUTOMATIC TEST DEVICE SWITCH TERMINLAS FOR TIMER CONTROL CIRCUITS OF 90-130 VOLTS ALTERNATING CURRENT OR UNFILTERED RECTIFIED ALTERNATING CURRENT ONE AMPERE MAXIMUM

6.4.2 *Test Circuit* — When the timer is connected to its power source timer control voltage will appear across terminal A and B and simultaneously across the alternating current side of the bridge rectifier. A very small current will flow due to capacitor C1 charging through R1-R2 and D6. During this period of charging, the silicon controlled rectifier is not conducting so that the impedance from terminals A to B is, too high to permit the timer control circuit to operate. When capacitor C1 reaches a potential of about 65 volts, the neon lamp will ignite and discharge the capacitor through current-limiting resistor R4 into the silicon controlled rectifier (SCR) gate. With the silicon controlled rectifier conducting, the impedance at terminals A and B is reduced to a very low value. Hence the timer will turn on for an exposure. The on period will last for at least ten cycles at the faster repetition rate. This will have the same effect as holding down the exposure switch for ten cycle or more and will allow testing of timers having a minimum time setting of 1/10 second or less. Recycling does not begin until the on period ends, so recycling time measurements are not affected by the length of the on period. The off period is adjustable from 1 to 10 cycles.

6.4.3 *Electrical Connections* — An oscilloscope shall be connected to the x-ray control primary circuit as shown in Fig. 2 so that it will be energized by the alternating current supply for the duration of the timed interval terminals A and B of the automatic test device, shall be connected to the timer being tested in place of its usual exposure initiating means.

6.4.4 *Test Procedure* — The timer shall be set for its shortest interval. The repetition rate control (R2 in Fig. 1) of the automatic test device shall be set for maximum resistance. The timer, when energized, will pulse.

The oscilloscope indicating the timed interval in cycles. The oscilloscope shall be closely observed under these conditions for a time sufficient to determine the consistancy of the timer in making the repeated exposures. Should occasional error be noted in the duration of the timed interval, its pattern shall be established as accurately as possible, for example, one bad exposure for every ten correct ones, etc. The resistance of the rate control, R2, of the automatic test device shall be slowly decreased while continuing to observe the oscilloscope pattern for any shortening of the timed interval or an increase in inconsistency, if any, were present originally. When this point is reached the control shall be advanced slightly to where the correct interval is once again observed. This setting shall represent the minimum period of de-energization that will permit the timer to properly reset.

6.4.5 *Measuring Timer Recycle Time* — The oscilloscope shall be connected to terminals A and B of the automatic test device in addition to the timer connections. The timer recycle time shall be read to the nearest cycle (or millisecond) from the oscilloscope screen (*see* Fig. 2).

6.4.6 *Test Value* — The minimum period of de-energization that will permit the timer to properly reset shall not be more than 1 cycle for electronic timers and 4 cycles for mechanical contactors.

NOTE — This test is only to be conducted where use demands.

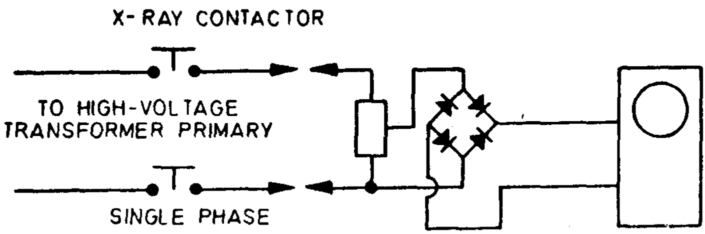


FIG 2 METHOD OF CONNECTING OSCILLOSCOPE X-RAY PRIMARY CIRCUIT TO ACCURATELY MEASURED TIMED EXPOSURE

6.5 Milliampere Stabilization Test

6.5.0 *General*— The rated supply voltage used for the milliampere stabilization test shall not vary by more than 2·5 percent and the frequency of the supply shall not vary by more than ± 1 percent.

6.5.1 *Test for Stabilization with Supply Voltage Changes*

6.5.1.1 The voltage to x-ray control shall be adjusted to the nominal voltage by adjusting the line voltage for operating the line voltage adjustment. The peak kilovoltage shall be set at 60 percent of rated output voltage and 0·2 second exposures shall be made at 50 percent of rated output current or greater. The values of milliamperes obtained shall be recorded as 'milliamperes for normal line voltage'.

6.5.1.2 The line voltage shall be set to 94 percent of nominal. The kilovoltage shall be set to the same indicated value as in **6.5.1.1**, but no other adjustments shall be made. The exposures called for in **6.5.1.1** shall be repeated and the values of milliamperes obtained shall be recorded as 'milliamperes for low line voltage'.

6.5.1.3 The supply line voltage shall be set to 106 percent of nominal. The kilovoltage shall be set to the same indicated value as in **6.5.1.1**, but no other adjustments shall be made. The exposures called for in **6.5.1.1** shall be repeated and the values for milliamperes obtained shall be recorded as 'milliamperes for high line voltage'.

6.5.1.4 *Test value* — The values of 'milliamperes for low line voltage' and the values of 'milliamperes for high line voltage' shall be compared with the values of 'milliamperes for normal line voltage'. The difference between these readings shall not exceed the percentage value indicated below :

X-ray equipment with rated output current	$\leqslant$ 100 mA	10 percent
X-ray equipment with rated output current and	$\leqslant$ 300 mA $>$ 100 mA	5 percent
X-ray equipment with rated output current	$>$ 300 mA	2·5 percent

6.5.2 *Test for Stabilization with Peak Kilovoltage Changes*

6.5.2.1 The x-ray equipment shall be supplied with rated line voltage. Peak kilovoltage shall be set at 75 percent of rated output voltage, and 0·2 second exposure shall be made at 25 and 75 percent of rated output current. The values of milliamperes shall be recorded as milliamperes for base peak kilovoltage.

6.5.2.2 The peak kilovoltage shall be raised to 90 percent of rated output voltage, but no other adjustments shall be made. The exposures called for in **6.5.2.1** shall be repeated, and the values of milliamperes obtained shall be recorded as milliamperes for the high peak voltage.

6.5.2.3 The peak kilovoltage shall be lowered to 60 percent of rated output voltage, but no other adjustments shall be made. The exposures called for in **6.5.2.1** shall be repeated, and the values of milliamperes obtained shall be recorded as milliamperes for the low peak kilovoltage.

6.5.2.4 *Test value* — The values of milliamperes for the high peak kilovoltage and the values of milliamperes for the low peak kilovoltage shall be compared with the values of milliamperes for the base peak percentage value indicated below :

X-ray equipment with rated output current	$\leqslant$ 100 mA	10 percent
X-ray equipment with rated output current and	$\leqslant$ 300 mA $>$ 100 mA	5 percent
X-ray equipment with rated output current	$>$ 300 mA	2·5 percent

6.5.3 *Test for Stabilization with Change of Frequency* — Under consideraation.

6.6 Timer Test for X-ray Control

6.6.1 *Class A Timers* — Class A Timers shall have a minimum setting of not more than one electrical cycle. Class A timing devices shall make and break the supply circuit to the x-ray tube at a phase angle chosen to minimize arcing or transients for the specific type of contactor and high-voltage generator. This will usually be approximately zero electrical degrees for mechanical contactors and thirty electrical degrees for electronic tube contractors. The Class A timing devices shall repeat at the same electrical angle consistently within ± 10 percent.

A timer shall not exceed those listed below :

Time in Seconds	*Maximum*
0·01 to 0·500	0·1 half cycle
0·501 to maximum range	2 percent

6.6.2 *Class B Timers* — Class B timers shall have a minimum setting of not more than three electrical cycles. Class B timing devices may make or break the supply circuit to the x-ray tube at random in respect to the position of the alternating current wave. The errors of Class B timers shall not exceed one half electrical cycle or 2 percent, whichever, is greater.

6.6.3 *Class C Timers* — Class C timers shall have a minimum setting of not more than six electrical cycles. Class C timing devices may make or break the supply circuit to the x-ray tube at random in respect to the position of the alternating current wave. The errors of Class C timers shall not exceed one electrical cycle or 5 percent, whichever, is greater.

6.6.4 *Class D Timers* — Class D timers shall have a minimum setting of not more than 0·25 seconds. Class D timing devices may make and break the circuit at random in respect to the position of the alternating current wave. The errors of Class D timers shall not exceed three electrical cycles or 6 percent, whichever is greater.

6.6.5 Oscilloscope shall be used for testing for '0' to '0·5' second. For measuring above 0·2 second, digital counter or synchronous clock may be used.

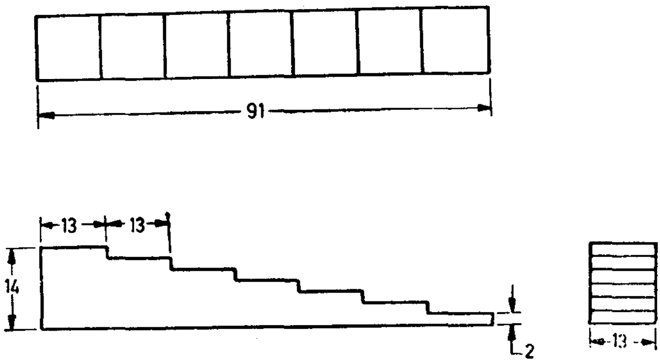
6.7 Stator Voltage and Current Test — For tubes of rotating anode type the stator voltage and current shall be verified for compliance with the limits specified by the manufacturer for these quantities.

6.8 Interlock Tests — All interlocks such as stator interlock, timer interlock, bucky interlock and tube rating interlock shall be tested as per manufacturer's specification where the interlocks are operated electrically or mechanically.

6.9 Installation Tests

6.9.1 *Step-Wedge Tests*

6.9.1.1 Figure 3 gives a dimensional sketch of step-wedge made of aluminium or aluminium alloy.



All dimensions in millimetres.

FIG. 3 STEP-WEDGE

6.9.1.2 *Test method* — Take a picture of the step-wedge at 2/3 of maximum kV at minimum mA setting, that is, 5 to 10 mA at say 25 percent of the rated maximum mA. This is to be used as reference radiograph. Keep kV and mA constant and take pictures at different mA stations given in the equipment. Compare the radiographs with test radiograph.

6.9.1.3 The penetration should be almost same in all the mA stations.

6.9.2 *Spinning Top Test*

6.9.2.1 A recommended sketch of spinning top is shown in Fig. 4.

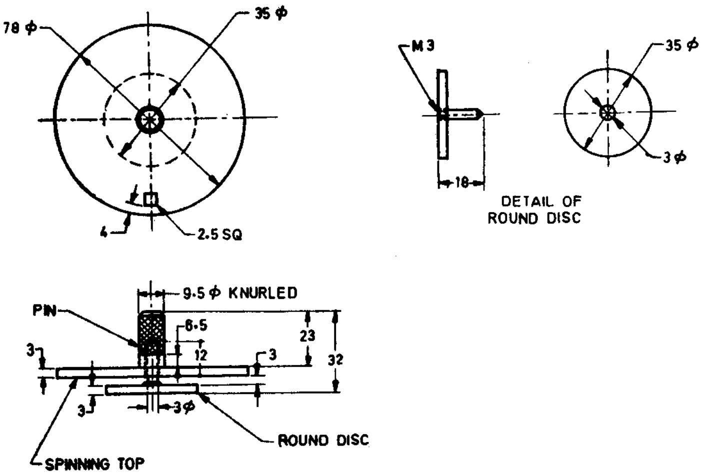
6.9.2.2 *Test method* — Set the control as approximately 2/3 of the peak kV and any mA station. Set the unit to 0·04, 0·05, 0·06 or nearest values. Take a radiograph. The radiograph with show time in seconds × 100 number of dots in full wave rectified equipment and $\frac{\text{time in seconds} \times 100}{2}$ number of dots in self and half-wave rectified equipment at 50 cycles.

NOTE — The step-wedge test and spinning top test are subject to availability of supply of film and darkroom facilities by the user.

6.10 Grid Pattern Test

6.10.1 Place the x-ray tube in such a position that the central ray is perpendicular to and intersects the centre of the grid.

6.10.2 The focus-grid distance shall be adjusted so that the focal spot of the x-ray tube is on the convergence line of the grid.



Part	*Material*
Pin	Spring steel
Round disc	Brass
Spinning top	Brass
Spinning top assembly	Brass

All dimensions in millimetres.

FIG. 4 SPINNING TOP

6.10.3 A radiograph shall be made of the grid alone, using the proper exposure for x-ray energy, focus-grid distance, film speed, and intensifying screens being used.

The radiograph shall be inspected for uniformity of grid pattern, freedom from splits, inclusion of foreign material, etc.

6.10.4 *Test Value* — The grid pattern shall be uniform, without abrupt changes in photographic density on the test film. The grid shall be free of splits and shall be free of inclusions of foreign material in the intended useful areas of the grid.

6.10.5 Number of grid lines and grid ratio shall be checked for compliance with the value specified by the manufacturer.

NOTE — For this purpose, manufacturer's test certificate may be accepted.

6.11 Grid Clean-up Test

6.11.0 For the purpose of securing comparable measurements, a photoelectric method of measuring grid clean-up is described because of its sensitivity and reproducibility. Alternate methods which produce comparable results may be used.

6.11.1 *Phantom* — A water phantom having an area of 300 × 300 mm and a depth of 200 mm shall be used. When a range of depths is desired, 100, 200 and 300 mm are recommended. The containers shall be made of acrylic plastic, polyethelene or any other material not containing heavier elements, such as sulphur or chlorine. The thickness of the bottom shall not exceed 10 mm.

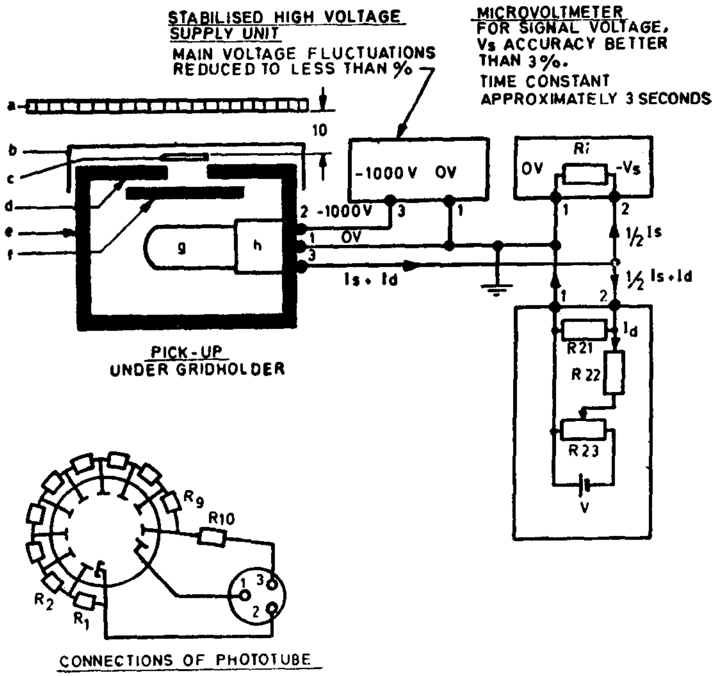
6.11.2 *X-ray Source* — The x-ray tube shall have a total (inherent + added) filtration of approximately 2 mm of aluminium at 60 kV and 4 mm of aluminium at 100 kV. The high voltage applied to the tube shall have a ripple of less than 10 percent. Grids shall be tested at 60 and 100 peak kilovolts.

6.11.3 *Radiation Detector* — A fluorescent screen incombination with a photo-multiplier shall be used as the radiation detector. The fluorescent screen shall be approximately 20 mm in diameter and shall be of a calcium tungstate medium-speed type, backed with 0·5 mm of aluminium for electron absorption. The photo-multiplier tube shall be of any type yielding at least 20 amperes per lumen. The photo-multiplier tube voltage shall be regulated within 0·1 percent (*see* Fig. 5).

6.11.4 *Test Procedure* — The x-ray tube focal spot shall be placed 1 m perpendicularly above the centre of the grid. The diameter of the x-ray beam at the surface of the grid towards the tube shall be 360 mm (except when measuring primary radiation only).

The grid shall be placed 10 mm below the bottom of the phantom. The distance from the bottom of the grid to the fluorescent screen shall be 20 mm. The photo-multiplier tube shall be shielded from ionizing radiation and exposed only to the visible light produced by the fluorescent screen (*see* Fig. 6). Scattered radiation alone shall be measured when the 5 mm diameter lead shield is placed above the phantom as shown in Fig. 6 with the grid removed, but all other factors remaining the same, relative scattered radiation will be indicated.

Total radiation I_t is measured when the lead shield is removed from the above phantom. With the grid in place, I'_t will be indicated, and with the grid removed, I_t will be indicated again. To measure primary radiation (I_p) only, a very narrow beam of x-ray must be used. It shall be collimated down to just over the area of the fluorescent screen. The water phantom, or narrower water container holding the same depth of water, shall be raised close to the x-ray tube to reduce any effects of scattered radiation from the small volume being irradiated (*see* Fig. 7). With the grid removed, I'_p will be indicated.



I_s = signal current

I_d = dark current

R_1 . . . . . .R_9 —100 kΩ

R_{10} . . . . . . —200 kΩ

$R_{21} = Ri \simeq 1$ MΩ

R_{22} = 100 MΩ

R_{23} = 1 MΩ should be adjusted to compensate I_d

V = 1·5 to 5 volts

a = Grid to be measured

b = Light tight 0·5 mm thick aluminium cover

c = Calcium tungstate, intensifying screen 20 mm diameter

d = 5 mm thick lead diaphragm with 20 mm diameter aperture

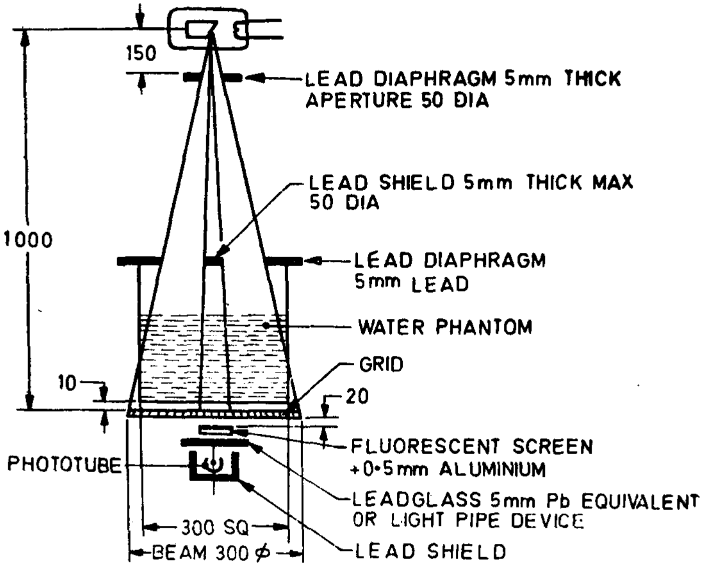
e = Light tight, 5 mm thick lead lined box

f = Lead glass, 5 mm Pb equivalent

g = Photo-multiplier tube with minimal noise and with a minimum sensitivity of 20 Am/lm

h = Tube holder with incorporated voltage divider

FIG. 5 GRID TRANSMISSION MEASURING EQUIPMENT



All dimensions in millimetres.

FIG. 6 SET UP FOR MEASURING SCATTERED AND TOTAL RADIATION

Compute the transmission and thereby, the bucky factor, selectivity and contrast improvement factor as follows :

$T = I'/I$ = Transmission,

$T_p = I'_p/I_p$ = transmission of primary radiation,

$T_s = I'_s/I_s$ = transmission of scattered radiation,

$T_t = I'_t/I_t$ = transmission of total radiation,

Bucky factor $B = I_t/I_t' = \frac{1}{T_t}$,

Selectivity $\Sigma = T_p/T_s$, and

Contrast improvement factor $K = T_p \times B = T_p/T_t$.

6.11.5 *Test Value* — The test values shall be as given in Table 2.

6.12 Potter-Bucky Motion and Synchronism Test

6.12.0 A potter-bucky shall be selected and set up in accordance with Fig. 8 and the method described in **6.12.1** to **6.12.7** shall be followed.

TABLE 2 TEST VALUES

(*Clause* 6.11.5)

Grid Ratio	Maximum Bucky Factor for Grids				Minimum Selectivity for Grids				Minimum Contrast Improvement Factors for Grid			
	60 kV$_P$		100 kV$_P$		60 kV$_P$		100 kV$_P$		60 kV$_P$		100 kV$_P$	
	Organic	Aluminium	Organic	Aluminium	Organic	Aluminium	Organic	Aluminium	Organic	Aluminium	Organic	Aluminium
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
4 : 1	3·90	—	3·10	—	3·60	—	2·50	—	2·10	—	1·80	—
5 : 1	4·70	5·10	3·70	3·70	5·00	5·00	3·10	2·90	2·50	2·50	2·00	2 00
6 : 1	5·20	5·50	4·00	4·00	5·90	5·70	3·60	3·30	2·90	2·60	2·30	2·20
8 : 1	6·40	7·40	5·20	5·20	8·80	8·30	5·10	4·70	3·20	3·10	2·70	2·60
10 : 1	—	8·50	—	6·00	—	11·70	—	6·00	—	3·60	—	3·00
12 : 1	7·60	9·80	6·40	7·00	13·50	14·80	8·10	7·80	3·70	3·80	3·40	3·30
16 : 1	8·70	—	7·80	—	19·50	—	12·50	—	4·20	—	3·90	—
5 : 1 Crossed	9·50	—	7·00	—	19 90	—	7·00	—	3·90	—	3·10	—
6 : 1 Crossed	—	13·10	—	8·30	—	26 90	—	8·30	—	4·20	—	3·30
8 : 1	13·30	—	10·60	—	65·50	—	15·60	—	4·90	—	4·20	—

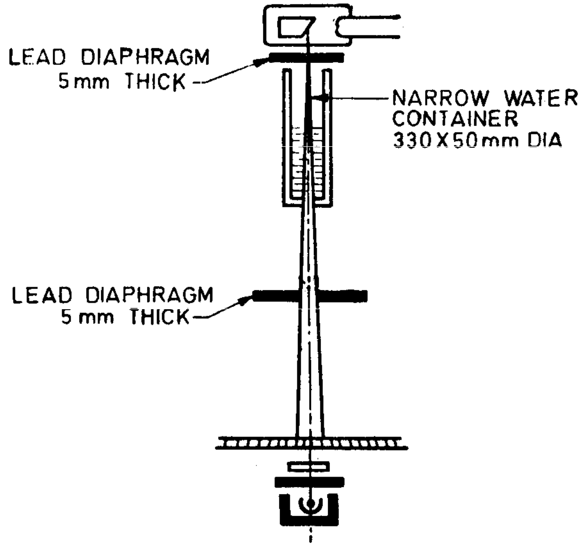
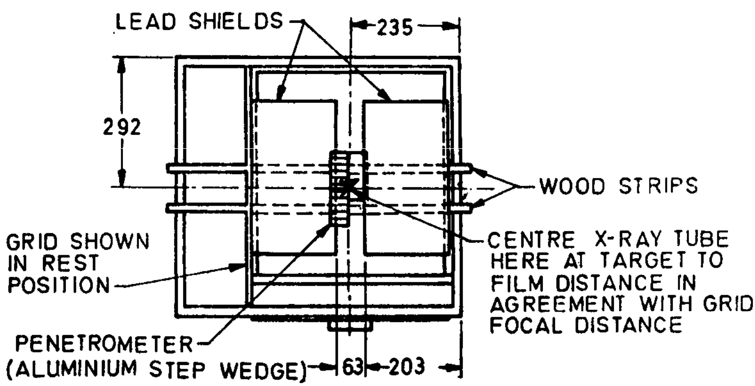


FIG. 7 SET UP FOR MEASURING PRIMARY RADIATION

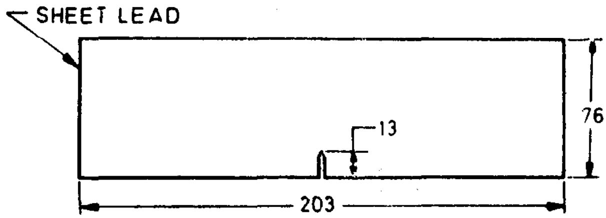
6.12.1 Obtain a piece of sheet, lead at least 76 mm × 203 mm × 1·6 mm thick. Cut a slot in the middle, of one long edge. Make the slot 13 mm long and from its end into a sharp V as shown in Fig. 9. This piece may be of some other size as long as its length is greater than two times



All dimensions in millimetres.

FIG. 8 SETTING UP OF POTTER BUCKY

the total travel of the grid. With adhesive type, tape fasten the slotted piece of lead to the top of the grid as shown in Fig. 10. Be sure the slot in the lead piece is directly over the centre of the grid.

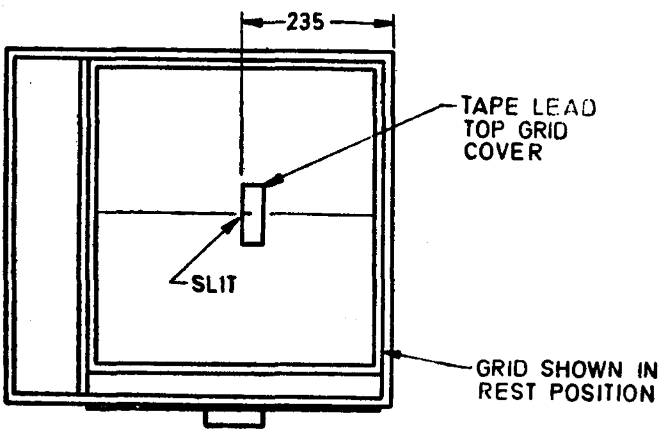


All dimensions in millimetres.

FIG. 9 SLOTTING OF LEAD SHEET

6.12.2 Place strips of wood across the potter-bucky frame in the direction shown and arrange the strips of wood to support two lead shields at least 203 × 355 × 1·6 mm thick as shown in Fig. 8.

6.12.3 Place an aluminium step wedge as shown in Fig. 8 so that one of its edges will rest on the lead shield. Be sure that the weight of the lead shields and the step wedge does not bend the wood strips down so that they contact the grid or grid carriage. If leaded rubber is used as



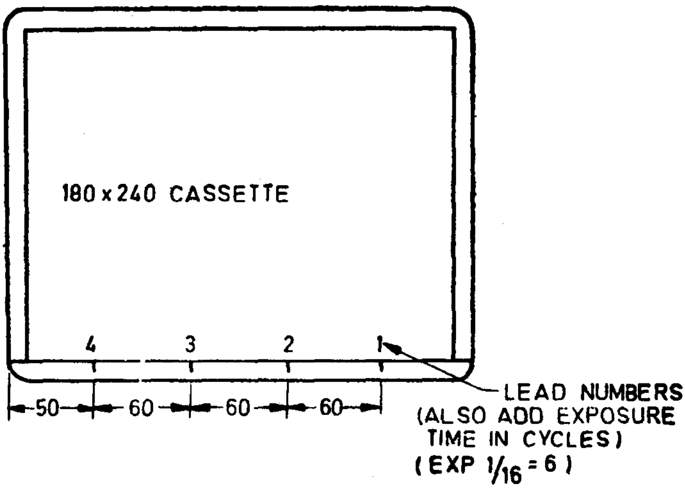
All dimensions in millimetres.

FIG. 10 FASTENING OF THE LEAD SHEET

shielding, additional wood strips may be necessary to prevent sagging of the shielding. It is very important to place the lead shields with respect to width and opening exactly as shown in Fig. 8.

6.12.4 Place the x-ray tube over the centre of the potter-bucky grid area and at the proper focal spot to grid distance as shown in Fig. 8.

6.12.5 Place a piece of adhesive tape on the edge of an 180 × 240 mm cassette with film and mark it in accordance with Fig. 11.

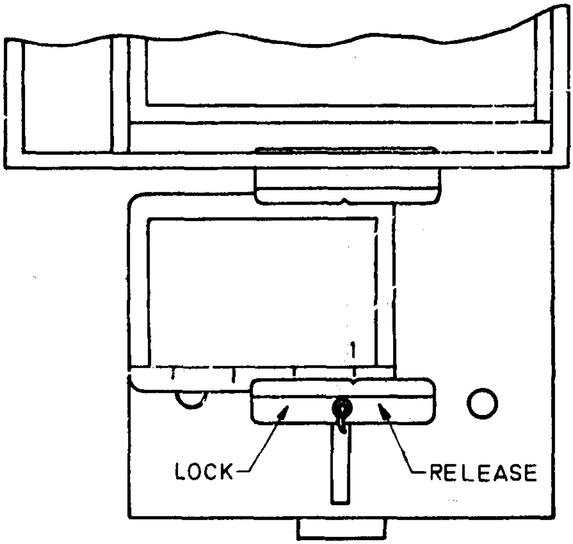


All dimensions in millimetres.

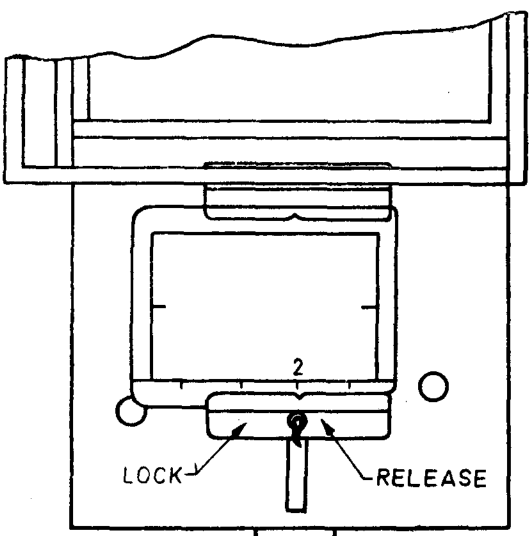
FIG. 11 MARKING OF THE CASSETTE

6.12.6 Insert the cassette into the cassette tray with the number 1 mark in line with the centre indication in the cassette tray clamps as shown in Fig. 12. Place the cassette tray into the potter-bucky in its proper position and make an exposure with the potter-bucky energized at the minimum time recommended for the grid used. Set the x-ray controls so that the aluminium step wedge will produce light to dark density ranges on the radiograph.

6.12.7 Move the cassette so that mark number 2 is in the centre of the tray as shown in Fig. 12 B and make another exposure of increased time. Continue in this manner as shown in Fig. 12 C and 12 D until the appropriate time range is covered.

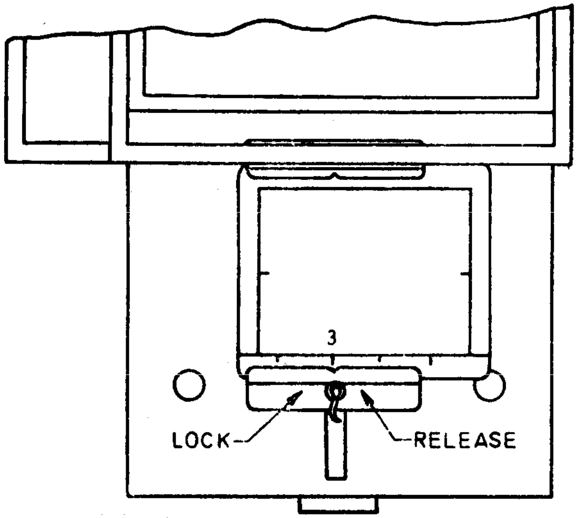


12A Position 1

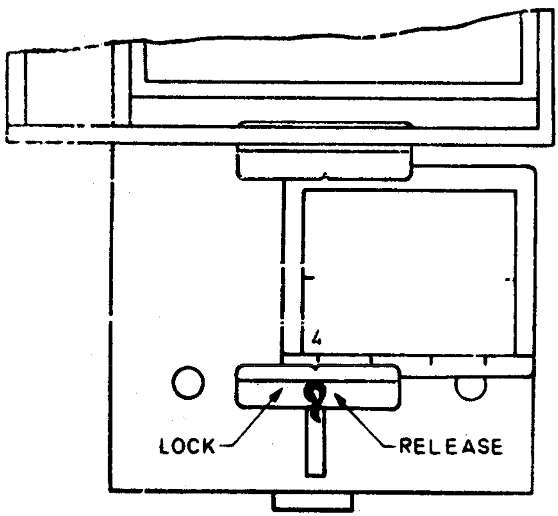


12B Position 2

FIG. 12 VARIOUS CASSETTE POSITIONS — *Contd*



12C Position 3



12D Position 4

FIG. 12 VARIOUS CASSETTE POSITIONS

6.12.8 Develop the film.

6.12.9 *Film Interpretation* — The radiograph produced by this test will indicate the following.

6.12.9.1 The grid speed will be indicated by the image of the slot in the piece of lead which was secured to the moving grid. The distance travelled during the exposure can be measured and, also the pulses of x-ray can be counted as a check against the timing indicated numerically on the film. The varying densities produced by the step wedge allow observation for grid lines and synchronization at specific time settings as indicated on the radiograph.

6.12.10 *Test Value* — The grid speed shall be such that all exposure times for which the potter-bucky is specified, the film exposed under the aluminium step wedge will be free of grid lines when the film is observed on an illuminator at a distance of 300 mm or greater.

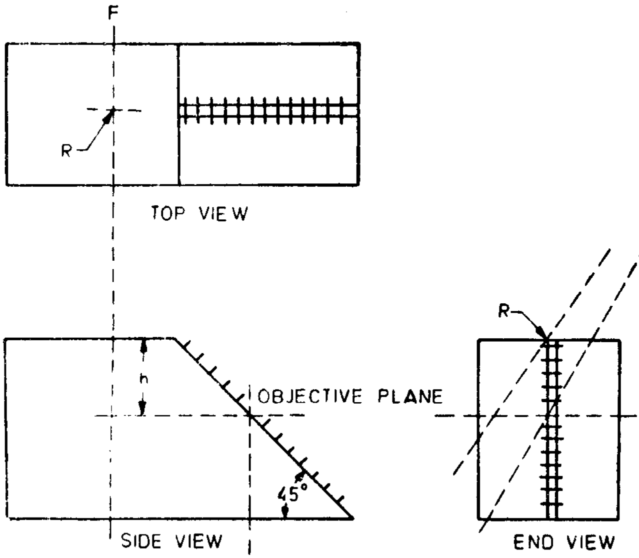
6.13 Rody Section Devices

6.13.1 *Exposure Angle and Location of Objective Plane* — The test object (*see* Fig. 13) shall consist of a sloping sheet of 0·5 mm thick lead foil containing a narrow slit marked off with opaque wires across the slit at 10 mm intervals in height. A horizontal sheet of lead foil shall be perforated with a single hole, *R* in line with the slit. The angle of the slope shall be 45 degrees.

Place the x-ray tube so that the central ray is perpendicular to the objective plane. Place the test object on the table top so that the single hole (*R*) is directly in line with the central ray. (For a rectilinear motion, the slit can be at right angles to thel movement, though it is not necessary.

An exposure shall first be made with the central ray perpendicular to the objective plane; this will record an image of the single hole and of the slit. The tube and system shall then be moved to any angle, the hole covered with lead, the hole uncovered; and a tomographic exposure made with the system adjusted to obtain the maximum exposure angle possible. The resulting radiograph should appear similar to that shown in Fig. 14 and shall be used to obtain the height of the plane (*E*). The exposure angle shall be derived from the excursion of the image of the hole to each side of the central dot (see Fig. 15), where $\tan\alpha_1 = (D—h)\ S_1/Ah$ $\tan\alpha_2 = (D—h)\ 32/Ah$.

The same procedure with a pluridirectional system will produce a radiograph similar to Fig. 16 which shows the trace of the dot with an elliptical motion. It may be shown that the exposure angles for the long and short axis of the ellipse can be derived in the same manner as for a rectilinear motion. The exposure angles for a more complex system can be obtained in the same manner.



NOTE — A sheet of lead covers the top and sloping side. The top has a small hole, *R*, in line with the slit. A slit shown in the end view is crossed by radiation opaque wires spaced 10 mm apart.

FIG. 13 THREE VIEWS OF TEST OBJECT FOR DETERMINING THE EXPOSURE ANGLE AND THE LOCATION OF THE OBJECTIVE PLANE

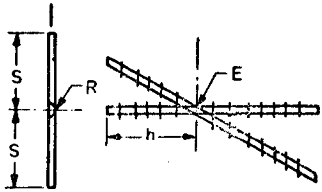
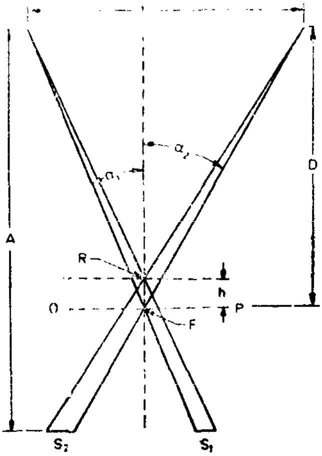


FIG. 14 TOMOGRAM OBTAINED FOR RECTILINEAR MOTION WITH THE TEST OBJECT SHOWN IN FIG. 13



NOTE — The values of h, S_1 and S_2 and the position E are obtained from a tomogram such as in Fig. 14. A is the focus-film distance and T is the distance moved by the focus during exposure.

FIG. 15 DIAGRAM FOR DETERMINING THE EXPOSURE ANGLE FOR RECTILINEAR MOTION

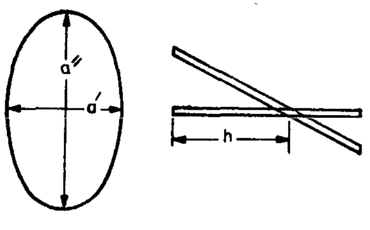


FIG. 16 TOMOGRAM OBTAINED FOR ELLIPTICAL MOTION WITH THE TEST OBJECT SHOWN IN FIG. 13

6.13.2 *Test Value*

6.13.2.1 *Objective plane* — The measured objective plane shall coincide with the indicated objective plane of the equipment within ± 2·5 mm.

6.13.2.2 *Exposure angle* — The measured exposure angle shall coincide with the indicated exposure angle (if any) of the equipment within ± 3 degrees.

6.13.3 *Flatness of Plane* — An estimate of the flatness of plane shall be made after the objective plane has been located in accordance with Fig. 13 as follows:

a) Insert any convenient wire mesh screen (flat over its entire surface to approximately 1 mm and of the same approximate area as the cassette) into the beam at the exact height of the plane as determined from Fig. 13 and exactly parallel to the table top.

b) Make a tomograph.

If the resultant radiograph displays the mesh in even focus, the plane is flat. If the plane curves, place the screen approximatly 2 to 3 mm lower and make a second tomograph and then 2 to 3 mm lower and make a third tomograph. Inspection of the three tomographs will establish the degree and direction of the plane curvature.

6.13.3.1 *Test value* — The measured flatness of plane shall be in accordance with the manufacturer's specified tolerance for flatness of plane.

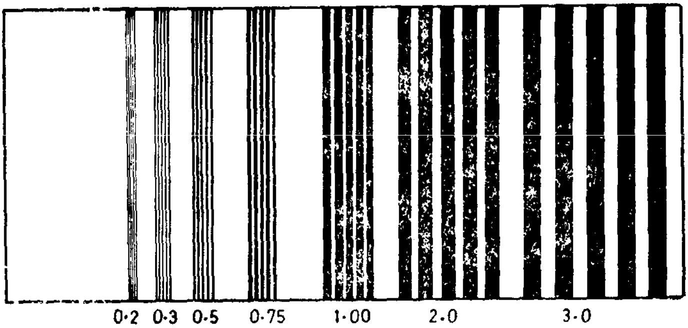
6.13.4 *Tomographic Resolution* — The tomographic resolution shall be determined by a test object consisting of a number of wires varying in diameter from 0·2 mm to 3·0 mm separated by their own diameter (*see* Fig. 17). (A simple way to obtain the wire separation is by winding two wires close together on a flat sheet of x-ray transparent material and then to remove one wire. The remaining wire on one side of the sheet can then be fixed with a cellulose adhesive. The wire on the other side is then removed by shearing in the adhesive. The wire on the other side is then removed by shearing in the edges of the sheet).

The test object shall be placed at an angle so that each wire intersects the objective plane. A tomograph shall be taken at total exposure angle of 30 degrees, with the objective plane 100 mm above the table top and with the movement at right angles to the length of the wires. The minimum diameter of wires which can be seen shall be taken as the measure of the tomographic resolution. This test also evaluates the mechanical stability and alignment of the apparatus.

6.13.4.1 *Test value* — The measured tomographic resolution shall be in accordance with the manufacturer's specified tomographic resolution capabilities.

6.13.5 *Section Thickness*

6.13.5.0 The section thickness shall be determined in accordance with the method given in **6.13.5.1**.



NOTE — Wires from 0·2 to 3 mm in diameter in groups of five are suitable and the support can be about 100 mm wide. Parallelled radiation-opaque wires are spaced by a distance equal to their own diameter. Wire solder can be used for 1 to 3 mm diameters.

FIG. 17 TEST OBJECT FOR DETERMINING TOMOGRAPHIC RESOLUTION OF THE FILM

6.13.5.1 *Test method* — Wind a cylinder 70 mm in diameter and 120 mm long with wire to a pitch of 10 mm (*see* Fig. 18A). The wire shall be 1 mm in diameter.

Fix a wire coaxially in the cylinder to serve as a test for alignment of focus with the object and film axis.

Place the cylinder so that its long axis is normal to the objective plane which should intersect the cylinder.

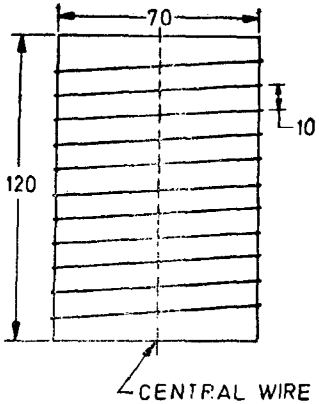
Take tomographs at the typical operating limits of the tomographic system.

The tomograph will show a portion of one of the wire turns more distinctly, and the area can be related to 360 degrees and the 10 mm pitch. For example, 90 × 10/3 602·5 mm (*see* Fig. 18B).

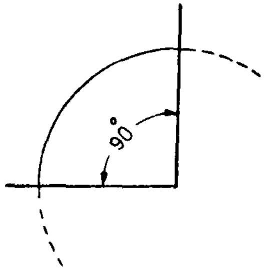
The 10 mm pitch can be increased to 20 to 40 mm where conditions are such that a whole turn of the 10 mm pitch is resolved.

Section thickness = arc × pitch/360.

6.13.5.2 *Test value* — The measured section thickness shall be within ± 80 percent of the section thickness specified by the manufacturer.



18A Cylindrical Test Object with a Helically-Wound Wire of 1 mm or More Diameter



18B Resultant Tomogram

FIG. 18 SECTION 'THICKNESS' TEST OBJECT POSITIVE CONTRAST

6.13.6 *Magnification Test* — The magnification of the image in relation of the object can simply be derived from the following formula:

$$\text{Magnification } M = \frac{\text{focal spot to film distance}}{\text{focal spot to objective plane distance}}$$

6.14 Test on X-ray Table — The conformity with the requirements of **3.11.2** shall be verified by fluoroscopic checkwith x-ray. The conformity with the requirements of **3.8.3** shall be checked with actual application of chemicals and dyes to be made on table and clean it with soap water. Conformity with **3.8.4** shall be checked with the radiation output measurement with suitable dosemeter. The conformity with the requirements of **3.8.8** shall be checked by actual measurement by means of a spring balance.

6.15 Test on Tube Stand — Compliance with the requirements of **3.9.4** shall be checked by measurement with spring balance.

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